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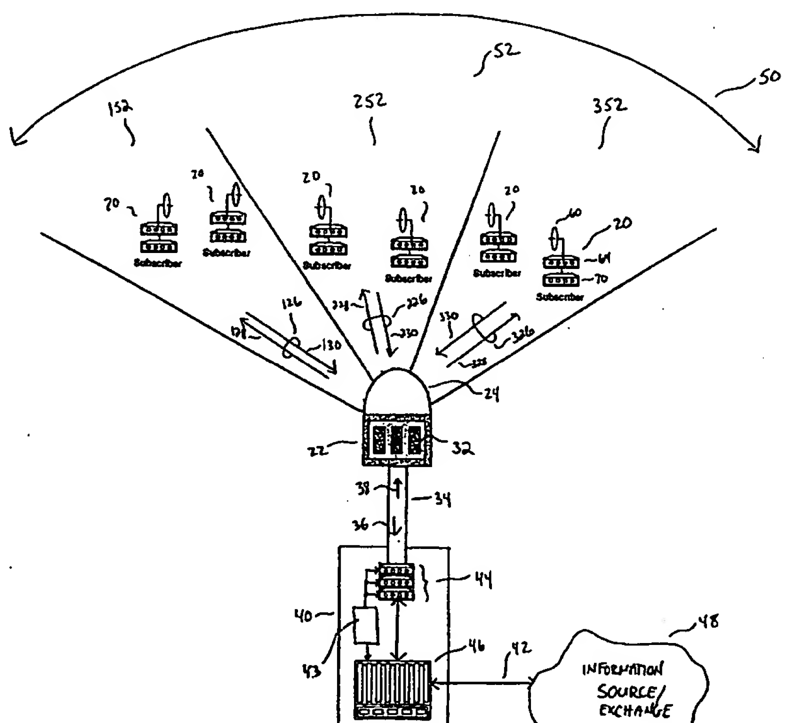

(57) Abstract: A hybrid cable/wireless communication system. Donwstream information is transported to one or more users via one or more physical communication links, such as a link employed in a CATV network infrastructure or cable plant. Upstream information is transported from the users on one or more wireless communication links. In one exemplary implementation, users may employ cable modems to decode the downstream information from the physical communication link and to encode the upstream information. An output of the user cable modem encoded with the upstream information is coupled to a cable-to-spread spectrum converter to transmit the upstream information on a spread spectrum frequency channel of the wireless communication link. In an alternative exemplary implementation, upstream information from the users is directly encoded on a spread spectrum frequency channel of the wireless communication link, which is decoded (demodulated) at a receiving end. A cable modem at the receiving end may receive the upstream information decoded from the wireless communication link and subsequently encode the upstream information on cable frequency channels for further upstream transmission.

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HYBRID CABLE/WIRELESS TWO-WAY COMMUNICATION SYSTEMS AND METHODS

Cross-Reference to Related Application

This application is a continuation-in-part of Application No. 09/287,144, filed April 6, 1999, which is hereby incorporated herein by reference.

Field of the Invention

The present invention relates to communication systems, and more particularly, to hybrid communication systems and methods that employ both wireless communication links and physical communication links.

Background of the Invention

Information may be transported from one location to another using physical communication links, such as wire conductors and/or fiber optics, or wireless communication links (transporting the information "over the air"). Various advantages and disadvantages are associated with both physical and wireless communication techniques, depending in part on the specific implementation and application of a given communication system.

One common example of a communication system that employs physical communication links is a cable television (CATV) network. In a conventional CATV network, a number of viewers are connected by physical communication links, including both wire conductor and fiber optic cables, to a common source of television signals. The interconnection of physical communication links that forms the infrastructure of the CATV network is often referred to as a "cable plant." Cable plants are deployed extensively around the world and are common especially in urban and suburban areas.

In a typical CATV network, a television receiver, or "headend," receives television signals from one or more satellite or conventional off-air antennas and converts these signals to electrical television signals. The electrical signals are transported on wire conductors to a number of electrical-to-optical signal converters that convert the electrical signals to optical television signals. The optical television signals then are transported throughout the cable plant on fiber optic cable links to fiber nodes which typically are distributed throughout a particular geographic area. At the fiber nodes, the optical signals are converted back to electrical television signals and transported to a variety of viewer destinations (e.g., houses, apartment buildings, and businesses) via wire conductors, such as coaxial cables. The

electrical television signals received by the viewers generally are within a frequency range of 54 MHz to 550 MHz, with a typical television channel having a bandwidth of 6 MHz.

Historically, most cable plants were deployed as one-way communication systems, providing television signals downstream from the headend receiver of the CATV network to a number of viewers. Some more recently deployed cable plants, however, provide two-way communications to and from viewers to accommodate the upstream transmission of signals from viewers toward the headend. Such an upstream transmission link may be used, for example, to allow for "pay-per-view" programming, in which a viewer may select a particular program or event for viewing and incur a per event charge. The upstream link also may be used, for example, to allow viewers to provide opinions in polls (viewing statistics), to provide for home shopping, to allow for remote reading of power meters and monitoring of alarm systems at the viewer's location, and the like.

While the development of CATV networks has reached a stage where two-way cable plants are desirable to accommodate a variety of services, deploying two-way cable plants and upgrading existing one-way cable plants to allow for two-way communications is often expensive and in some cases cost-prohibitive. Hence, while one-way cable plants are widely deployed, especially in urban and suburban areas, currently only about 25% of existing cable plants are capable of two-way communications.

Additionally, the total information carrying capacity of the upstream communication link of a conventional two-way cable plant generally is more limited than that of the downstream link. For example, the upstream communication link of a conventional two-way cable plant typically includes signals in a frequency range of from 5 MHz to 30 MHz (a total link bandwidth of 25 MHz), while the downstream link typically includes signals in a wider frequency range of from 54 MHz to 550 MHz (a total link bandwidth of almost 500 MHz), as discussed above.

In view of the foregoing, the communications industry has sought alternatives to communication systems having a physical communication link infrastructure, such as CATV networks, to bring robust high capacity two-way communications to a number of users.

Wireless communication systems offer an alternative to communication systems employing physical communication links. For example, wireless communication systems may be preferable, particularly in geographic locations such as remote rural areas, areas having difficult terrains, or urban areas that are overly-congested with physical communication links, where it may be difficult and/or cost-prohibitive to deploy new or additional wire conductors

or fiber optics. Rather than transporting information on one or more physical communication links, wireless systems radiate information carriers from one or more source antennas over the air throughout a geographic coverage area. The information carriers are received by one or more destination antennas at desired locations. Communication links in a wireless system generally may be defined by the radiation profiles of the information carriers, or "frequency channels," which carry the information. As with physical communication links, the information transported across wireless links may include, for example, voice or video information, graphical or textual information, raw data, compressed or encrypted data, and various other types of information.

While wireless communication systems provide a viable and often preferable alternative technique of interconnecting a number of users, it may not be economically feasible in some areas, however, to replace existing communication systems employing physical communication links with wireless communication systems. Additionally, some cosmetic aspects of wireless communication systems, such as antennas mounted on towers or buildings, may be undesirable for some applications. For example, some residential communities may have various ordinances in connection with the appearance of the community, which may preclude erecting a structure such as a large antenna on a residence or residential property.

Furthermore, while wireless communication systems generally may be easier to deploy in some terrains and topographies, some types of wireless communication links may be susceptible to particular environmental issues. For example, some narrow beamwidth or directional information carriers that are radiated on wireless communication links may require an essentially clear line of sight between source and destination antennas (e.g., free of trees and other landscape obstacles). Such a requirement may pose particular challenges, for example, in some suburban and low-lying wooded areas. In contrast, line of sight issues typically are less problematic in wireless communication systems in which antennas may be mounted at sufficiently high altitudes, or in wireless communication systems using information carriers that are radiated in a multi-directional or omni-directional manner. Additionally, line of sight issues rarely, if ever, present a problem in communication systems employing physical communication links.

In view of the foregoing, it should be appreciated that wireless communication links and physical communication links each have respective advantages and disadvantages, depending in part on the environment, implementation, and application of a given communication system.

Summary of the Invention

One embodiment of the invention is directed to a two-way communication method, comprising acts of transporting first information to at least one user on at least one physical communication link coupled to the at least one user, and transporting second information from the at least one user on at least one wireless communication link coupled to the at least one user.

Another embodiment of the invention is directed to a method of transporting data between a relay station and at least one fixed user. The method of this embodiment comprises acts of receiving at the relay station at least one first wireless frequency channel over the air, the at least one first wireless frequency channel carrying first data, converting the at least one first wireless frequency channel to at least one first frequency channel carrying the first data, and transmitting the at least one first frequency channel from the relay station to the at least one fixed user over at least one physical communication link. The method further comprises acts of transmitting at least one second wireless frequency channel over the air from the at least one fixed user to the relay station, the at least one second wireless frequency channel carrying second data, receiving the at least one second wireless frequency channel over the air at the relay station, converting the at least one second wireless frequency channel to at least one third wireless frequency channel carrying the second data, and transmitting from the relay station the at least one third wireless frequency channel over the air.

Another embodiment of the invention is directed to an information station including premises equipment to be used by a user, wherein the premises equipment receives first information and outputs second information. The information station of this embodiment comprises a first port, coupled to at least one physical communication link, through which to receive the first information transmitted to the information station on the at least one physical communication link, and a second port, coupled to at least one wireless communication link, through which to transmit the second information from the information station on the at least one wireless communication link.

Another embodiment of the invention is directed to a relay station, comprising a first port, coupled to at least one two-way communication link, through which to receive first information and to transmit second information on the at least one two-way communication link, a second port, coupled to at least one user physical communication link, through which to transmit the first information on the at least one user physical communication link, and a third

port, coupled to at least one user wireless communication link, through which to receive the second information on the at least one user wireless communication link.

Another embodiment of the invention is directed to a system, comprising a relay station to transport information, and at least one information station including premises equipment to be used by a user, wherein the premises equipment receives first information and outputs second information. In this embodiment, the at least one information station is coupled to the relay station to receive the first information from the relay station on at least one user physical communication link and to transmit the second information to the relay station on at least one user wireless communication link.

Another embodiment of the invention is directed to a hybrid cable/wireless communication system, comprising a base station to transmit downstream information and to receive upstream information on at least one two-way broadband wireless communication link, at least one fixed subscriber station, coupled to the at least one two-way broadband wireless communication link, to transmit at least some of the upstream information to the base station and to receive at least some of the downstream information from the base station, and at least one relay station. The relay station of this embodiment includes a first port, coupled to the at least one two-way wireless communication link, through which to receive at least some of the downstream information from the base station and to transmit at least some of the upstream information to the base station, a second port, coupled to at least one user physical communication link, through which to transmit the at least some of the downstream information on the at least one user physical communication link, and a third port, coupled to at least one user wireless communication link, through which to receive the at least some of the upstream information on the at least one user wireless communication link.

Another embodiment of the invention is directed to a spread spectrum-to-cable converter. The spread spectrum-to-cable converter of this embodiment comprises a spread spectrum receiver to receive at least one spread spectrum encoded frequency channel, wherein the at least one spread spectrum encoded frequency channel carries information. The spread spectrum receiver decodes the at least one spread spectrum encoded frequency channel and outputs the information. The spread spectrum-to-cable converter also includes a cable modulator, coupled to the spread spectrum receiver, to receive the information output by the spread spectrum receiver and to modulate at least one cable frequency channel with the information. The cable modulator outputs the at least one modulated cable frequency channel.

Another embodiment of the invention is directed to a cable-to-spread spectrum converter. The cable-to-spread spectrum converter of this embodiment comprises a cable demodulator to receive at least one cable frequency channel carrying information, wherein the cable demodulator demodulates the at least one cable frequency channel and outputs the information. The cable-to-spread spectrum converter also includes a spread spectrum transmitter, coupled to the cable demodulator, to receive the information output by the cable demodulator and to encode at least one spread spectrum encoded frequency channel with the information. The spread spectrum transmitter transmits the encoded at least one spread spectrum encoded frequency channel.

Brief Description of the Drawings

The accompanying drawings are not intended to be drawn to scale. In the drawings, each identical or nearly identical component that is illustrated in various figures is represented by a like numeral. For purposes of clarity, not every component may be labeled in every drawing.

Fig. 1 is a diagram of a wireless communication system employed in a hybrid cable/wireless communication system according to one embodiment of the invention;

Fig. 2 is a diagram of a subscriber station of the wireless communication system of Fig. 1, according to one embodiment of the invention;

Fig. 3 is a diagram of a relay station and a number of user stations of a hybrid cable/wireless communication system, according to one embodiment of the invention;

Fig. 4 is a diagram showing various components of the relay station and one user station of the hybrid communication system shown in Fig. 3, according to one embodiment of the invention; and

Fig. 5 is a diagram showing various components of the relay station and one user station of the hybrid communication system shown in Fig. 3, according to another embodiment of the invention.

Detailed Description

The present invention is directed to hybrid cable/wireless communication systems and methods which employ various concepts and features related to both wireless communication links and physical communication links. For example, one embodiment of the invention is directed to a two-way communication system and method in which downstream information is

transported to one or more users via one or more physical communication links, and upstream information is transported from the users via one or more wireless communication links.

As discussed above, some CATV network cable plants may provide for two-way communications. However, most existing CATV network cable plants currently deployed in many urban and suburban areas provide only for one-way downstream communications to users. Additionally, those cable plants that do provide for two-way communications typically have less information carrying capacity in an upstream direction (approximately 25-37 MHz bandwidth) than in a downstream direction (approximately 500 MHz) bandwidth.

In view of the foregoing, Applicants have appreciated that it would be beneficial to utilize, modify, and/or expand upon existing networks of physical communication links used in primarily one-way communication systems or limited capacity two-way communication systems (such as CATV networks) to provide a variety of high-capacity two-way information services to a number of users. Accordingly, in one embodiment of a hybrid cable/wireless two-way communication system of the present invention, downstream information is received by one or more users via a cable plant of a CATV network, for example, and upstream information is transmitted by the users over one or more high-capacity wireless communication links.

In various aspects, hybrid cable/wireless communication systems and methods according to the present invention may be particularly well-suited for locations such as urban and suburban areas, or residential areas in general. For example, in one aspect of the present invention, environmentally robust upstream wireless communication from one or more users using relatively small antennas may provide an aesthetically pleasing solution for high-capacity two-way communications in areas where existing physical communication links are used for downstream communication to the users.

Following below are more detailed descriptions of various embodiments of hybrid cable/wireless two-way communication systems and methods according to the present invention. It should be appreciated that various aspects of the invention as outlined below may be implemented in any of numerous ways, as the invention is not limited to any particular manner of implementation. Examples of specific implementations are provided for illustrative purposes only.

In one embodiment of the present invention, a hybrid cable/wireless communication system builds upon various concepts related to a two-way broadband wireless communication system. One example of such a wireless communication system is described in commonly

assigned U.S. patent application serial no. 09/287,144, entitled POINT-TO-MULTIPOINT TWO-WAY BROADBAND WIRELESS COMMUNICATION SYSTEM (hereinafter the "wireless system application"), filed April 6, 1999, and incorporated herein by reference.

Referring to Fig. 1 of the present disclosure, in one embodiment of a wireless communication system described in the wireless system application, information is transported between an information source or exchange 48 (e.g., a data network) and one or more subscriber stations 20, or between two or more subscriber stations 20. The information transported may include, for example, voice or video information, graphical or textual information, raw data, compressed or encrypted data and various other types of information. The subscriber stations 20 are dispersed over a geographic coverage area 52 having a number of sectors 152, 252, and 352. Each subscriber station 20 is fixed in location within a given sector and may serve one or more users.

In the system of Fig. 1, a base station 22 transmits information to, and receives information from, the subscriber stations 20 over independent two-way broadband wireless communication links 126, 226, and 326. Each communication link 126, 226, and 326 is associated with a respective sector 152, 252, and 352 of the coverage area 52. It should be appreciated that while Fig. 1 shows a coverage area 52 spanning an azimuth 50 of less than 360° and being divided into three sectors, the coverage area 52 may span an azimuth of up to 360° and may be divided into any number of sectors having various widths (angles).

Each wireless communication link 126, 226, and 326 in the system of Fig. 1 includes at least one "downstream" information carrier which carries information to one or more subscriber stations 20, and at least one "upstream" information carrier which carries information from one or more subscriber stations. The downstream and upstream carriers of the communication link 126 are indicated in Fig. 1 by reference characters 128 and 130, respectively. Similarly, the downstream and upstream carriers of link 226 are indicated in Fig. 1 by reference characters 228 and 230, respectively, and the downstream and upstream carriers of link 326 are indicated in Fig. 1 by reference carriers 328 and 330, respectively.

Examples of frequency ranges suitable for the information carriers of the communication links 126, 226, and 326 shown in Fig. 1 include, but are not limited to, the Multi-point Distribution Services (MDS) spectrum from 2.15 GHz to 2.156 GHz, the Multi-channel Multi-point Distribution Services (MMDS) spectrum from 2.5 GHz to 2.686 GHz, the Wireless Communication Services (WCS) spectrum, which is a 30 MHz band at approximately 2.3 GHz, the Industrial, Scientific, and Medical spectrum (ISM) having one band from 2.4

GHz to 2.485 GHz and another band above approximately 5.8 GHz, the Wireless Local Loop Band from approximately 3.4 to 3.6 GHz, the Unlicensed National Information Infrastructure (U-NII) spectrum from 5.15 GHz to 5.35 GHz and from 5.725 GHz to 5.825 GHz, and the Local Multi-point Distribution Services (LMDS) spectrum, near 28 GHz. In general, the wireless communication links 126, 226, and 326 may use information carriers within a frequency range of approximately 1 GHz to 40 GHz, including spectrum which may or may not be presently developed or licensed by the Federal Communications Commission (FCC). In one aspect of the embodiment of Fig. 1, the downstream and upstream carriers of the links 126, 226, and 326 each has an information carrying capacity of at least 10 Mbps (Megabits per second).

In the embodiment of Fig. 1, a dielectric lens-based sectored antenna system 24 is employed at the base station 22 to transport information to and from the subscriber stations 20. The system of Fig. 1 also includes a switching infrastructure 40 which connects the sectored antenna system 24 to the information source/exchange 48. The switching infrastructure 40 directs the flow of information between the information source/exchange 48 and the subscriber stations 20, or between two or more subscriber stations 20, by way of the sectored antenna system 24. The antenna system 24 is coupled to the switching infrastructure 40 using an intermediate communication link 34, which employs upstream and downstream information carriers 36 and 38, respectively. In one aspect of the embodiment of Fig. 1, the information carriers 36 and 38 each has a frequency in a range that is different from that of the wireless communication links 126, 226, and 326 between the antenna system 24 and the subscriber stations 20.

The base station 22 shown in Fig. 1 also includes one or more transceivers 32, coupled to the intermediate communication link 34 and to the antenna system 24. The transceivers 32 convert the upstream and downstream information carriers of the wireless communication links 126, 226, and 326 to respective upstream and downstream information carriers of the intermediate communication link 34.

In the embodiment of Fig. 1, the switching infrastructure 40 may include one or more modems 44 coupled to the intermediate communication link 34 to transmit information to, and receive information from, the base station 22 via the information carriers 38 and 36, respectively. The switching infrastructure 40 may also include switching equipment 46, which is coupled via an external communication link 42 to the information source/exchange 48, and coupled to the modems 44. The switching equipment 46 transports information to and from

any of the modems 44, or between any of the modems 44 and the external communication link 42, in a predetermined manner, as discussed further below. Examples of switching equipment 46 suitable for the communication system shown in Fig. 1, include, but are not limited to, high speed internet switches, asynchronous transfer mode (ATM) switches, and data routers.

In the switching infrastructure 40 shown in Fig. 1, the modems 44 modulate, or "encode," one or more downstream information carriers 38 of the intermediate communication link 34 with information received from the switching equipment 46, to transmit the information to the base station 22. The modems 44 also demodulate, or "decode," one or more upstream information carriers 36 received from the base station 22 over the intermediate communication link 34 to obtain or recover information, which the modem then transmits to the switching equipment 46. A variety of carrier modulation and demodulation techniques may be employed by the modems 44 in various implementations of the system of Fig. 1. Examples of modulation/demodulation techniques employed by the modems 44 suitable for purposes of the system of Fig. 1 include, but are not limited to, binary phase shift keying (BPSK), M-ary phase shift keying, various types of quadrature amplitude modulation (QAM), including quadrature phase shift keying (QPSK or QAM-4), orthogonal frequency division multiplexing (OFDM), vector orthogonal frequency division multiplexing (VOFDM), and coded orthogonal frequency division multiplexing (COFDM). In one aspect of the embodiment of Fig. 1, the modems 44 may be similar to any one of a number of modem types commonly employed in CATV networks, or "cable" modems.

Additionally, the modems 44 may employ various techniques for associating particular information with a particular subscriber station 20. For example, in one or more sectors, a modem 44 may employ time division multiple access (TDMA) techniques, in which each of the upstream and downstream frequency channels is divided into a plurality of time periods and at least one time period is assigned to each subscriber station within the sector. Alternatively, in one or more sectors, a modem 44 may employ code division multiple access (CDMA) techniques, in which information associated with a particular subscriber station is modulated and demodulated by (or correlated and decorrelated with) a unique digital reference code also associated with the particular subscriber station. CDMA modulation and demodulation is discussed further below, in connection with Figs. 3-5.

Fig. 1 also shows that the switching infrastructure 40 may include a processor 43 and may also include a memory or storage unit (not shown) coupled to the processor 43. The processor 43 serves to coordinate the activities of the modems 44 and the switching equipment

46. The processor 43 may be either a hardware-oriented controller and/or may include one or more computers that execute one or more programs (e.g., software, microcode) to perform various functions in connection with the operation of the modems 44 and the switching equipment 46. For example, one or more computers serving as the processor 43 may execute network management oriented computer code to control the flow of information through the system of Fig. 1.

In one aspect of the embodiment of Fig. 1, the information source/exchange 48 may be, for example, a packet-switched data network. In packet-switched data networks, typically a source address and a destination address are included in a "packet" of data. In this aspect, the switching equipment 46, the processor 43, and the modems 44 may be constructed and arranged so as to direct information, in the form of data packets, between the information source/exchange 48 and an appropriate subscriber station 20, or between two or more subscriber stations 20, as determined by the respective source and destination addresses of each data packet. In this manner, one or more subscriber stations 20 may communicate with one another and with the information source/exchange 48 through the switching equipment 46 via data packets. As discussed above, the processor 43 of the switching infrastructure 40 may perform a variety of functions (e.g., network management functions) in connection with the operation of the modems 44 and the switching infrastructure 46 to appropriately direct the flow of the data packets through the system of Fig. 1.

The information source/exchange 48 to which the system of Fig. 1 is connected may be a local or wide area network, and in particular may be an Ethernet or packet-switched data network such as the Internet, or a telephony infrastructure using Internet protocol or other data protocol. Accordingly, the embodiment of a wireless communication system shown in Fig. 1 may provide a variety of communication services to users served by the subscriber stations 20, such as video conferencing, telephony, high-speed Internet access, and two-way high-speed voice and data transfer.

Fig. 2 illustrates a subscriber station 20, according to one embodiment of the wireless communication system shown in Fig. 1. In Fig. 2, the subscriber station 20 is shown deployed in a structure 78, such as a residence, office building, or the like. The subscriber station 20 may include a directional antenna 60 which, for example, may be mounted to the structure 78 via a mount 76 or may be affixed to a tower in close proximity to the structure 78. The directional antenna 60 transmits information encoded on one or more upstream information carriers 30 to the base station 22 (shown in Fig. 1), and receives information encoded on one or

more downstream information carriers 28 transmitted from the base station over the two-way broadband wireless communication link 26. The wireless communication link 26 of Fig. 2 is exemplary of any one of the wireless communication links 126, 226, and 326 shown in Fig. 1.

In one embodiment, the directional antenna 60 of the subscriber station 20 shown in Fig. 2 may be, for example, a mesh parabolic antenna. The directional antenna 60 is coupled via a link 62 to a subscriber transceiver 64, which is in turn coupled to an internal subscriber communication link 66. In one aspect of this embodiment, the internal subscriber link 66 uses information carriers 68 and 69 having a frequency within a range that is different from that of the information carriers 28 and 30 of the wireless communication link 26. Accordingly, the subscriber transceiver 64 converts, for example, the downstream carrier 28 of the link 26 to the downstream carrier 68 of the link 66. Likewise, the transceiver 64 converts the upstream carrier 69 of the link 66 to the upstream carrier 30 of the link 26 for transmission by the directional antenna 60.

The subscriber station 20 shown in Fig. 2 also includes a subscriber modem 70 to transport information between the internal subscriber communication link 66 and subscriber premises equipment 74. The subscriber modem 70 encodes and decodes the information carriers 68 and 69 of the internal subscriber communication link 66 in a manner similar to that discussed above in connection with the modems 44 of the switching infrastructure 40 shown in Fig. 1. In one embodiment, the subscriber modem 70 need only accommodate communication between the base station 22 and the subscriber station 20 in which the modem 70 is employed, unlike the modems 44 of the switching infrastructure 40 which typically accommodate communication between the base station 22 and a number of subscriber stations 20. The premises equipment 74 is coupled to the subscriber modem 70 via link 72 and may include, for example, one or more personal computers, video monitors, telephones, and the like. Additionally, for embodiments in which the information source/exchange 48 of Fig. 1 is a packet-switched data network, the premises equipment 74 may include a packet-switched network interface (not shown) that couples various devices included in the premises equipment 74 to the link 72.

In one embodiment, the subscriber station 20 shown in Fig. 2 may serve a number of actual users. For example, the subscriber station 20 may be an office building serving one or more businesses, a multiple dwelling unit including a number of residences, or a government facility having a number of branches. In one aspect of this embodiment in which the information source/exchange 48 of Fig. 1 is a packet-switched data network, each user of the

subscriber station 20 may have a unique address. In this aspect, information in the form of data packets transported between the base station 22 of Fig. 1 and the subscriber station 20 (each packet having a source and destination address) may be directed to and from the appropriate user in the subscriber station 20 by virtue of the unique address, as discussed above in connection with the switching equipment 46 shown in Fig. 1.

With reference again to Fig. 1, in one embodiment of a hybrid cable/wireless communication system according to the present invention, one or more "relay stations" may be deployed in one or more sectors 152, 252, and 352 of the coverage area 52 along with the subscriber stations 20. Such a relay station may serve, for example, to couple any one of the two-way wireless communication links 126, 226, and 326 (depending on the sector in which the relay station is deployed) to one or more other communication systems employing physical communication links. The physical communication links in turn may transport information originally carried on the wireless communication links 126, 226, or 326, for example, to one or more users. In this manner, the wireless communication system of Fig. 1 may be "combined" with another communication system employing physical links to form a hybrid cable/wireless system, according to one embodiment of the invention. In one aspect of this embodiment, one or more relay stations may be deployed in the coverage area 52 of the wireless system of Fig. 1 to expand the system of Fig. 1 to include newly deployed physical communication links that are not necessarily associated with any other communication system. In another aspect, one or more relay stations may be deployed in the coverage area 52 to couple the system of Fig. 1 to one or more existing physical communication links of another communication system.

Fig. 3 is a diagram of a hybrid cable/wireless communication system according to one embodiment of the invention. The embodiment of Fig. 3 includes a relay station 20A and one or more information stations 20B, or "user" stations. The user stations 20B are coupled to the relay station 20A to receive downstream information from the relay station 20A on one or more physical communication links 90, and to transmit upstream information to the relay station 20A on one or more wireless communication links 100. While Fig. 3 shows four user stations 20B coupled to the relay station 20A, it should be appreciated that the hybrid cable/wireless communication system of Fig. 3 is not necessarily limited to four user stations. In general, a hybrid cable/wireless communication system according to various embodiments of the invention may be capable of supporting any number of user stations.

In the embodiment of Fig. 3, the relay station 20A includes a first port 134, coupled to a two-way wireless communication link 26 via a first antenna 60A and a link 62A. In one

implementation of the system of Fig. 3, the first antenna 60A of the relay station 20A, as in the subscriber station 20 of Fig. 2, may be a directional antenna, although other types of antennas may be suitable for other implementations.

With reference again to Fig. 1, in one embodiment of the invention, one or more relay stations 20A may be deployed in any of the sectors 152, 252, and 352 of the coverage area 52 of the wireless communication system shown in Fig. 1. In view of the foregoing, the two-way wireless communication link 26 of Fig. 3 may be exemplary of any one of the two-way wireless links 126, 226, and 326 shown in Fig. 1.

In particular, as in Fig. 2, the two-way wireless link 26 of Fig. 3 includes a downstream carrier 28 and an upstream carrier 30. In one aspect of the embodiment of Fig. 3, the downstream and upstream carriers 28 and 30, respectively, have frequencies within the Multi-channel Multi-point Distribution System (MMDS) frequency spectrum (from approximately 2.5 GHz to 2.7 GHz). In other aspects, information carriers on the wireless communication link 26 having frequencies in other spectra may be employed, as discussed above in connection with Fig. 1. Additionally, in yet other aspects of the embodiment of Fig. 3, the downstream and upstream carriers 28 and 30 may transport information to and from the relay station 20A using, for example, time division multiple access (TDMA) techniques or code division multiple access (CDMA) techniques, as discussed above in connection with Fig. 1 and in the wireless system application referenced above.

While Fig. 3 shows the relay station 20A as including the antenna 60A to transmit and receive frequency carriers 28 and 30 of the wireless communication link 26, it should be appreciated that the invention is not so limited. In particular, the first port 134 of the relay station 20A may be coupled to wireless and/or physical communication links which transport downstream and upstream carriers 28 and 30 in a variety of frequency ranges to and from a variety of information sources/exchanges. In some embodiments in which only one or more physical communication links are coupled to the first port 134, the antenna 60A and the link 62A may not be required.

As shown in Fig. 3, the relay station 20A also includes a second "port" 132 which is coupled to one or more physical communication links 90. The physical communication link 90 may be formed by, for example, one or more wire conductors such as coaxial cables, one or more fiber optic cables, or a combination of wire conductors and fiber optics. In the embodiment of Fig. 3, each user station 20B is also coupled to the physical communication

link 90. The relay station 20A transmits downstream information through the second port 132 to one or more of the user stations 20B via the physical communication link 90.

In one embodiment, the physical communication link 90 shown in Fig. 3 may be a portion of a cable plant of a CATV network. As discussed above, a cable plant refers to the interconnection of physical communication links that form the infrastructure of a CATV network. For example, in one embodiment, the relay station 20A may be deployed along with, or as part of, a "microcell" station (hereinafter microcell) of a mobile wireless communication system that is integrated with the cable plant of a CATV network. Microcells in mobile wireless communication systems typically include one or more antennas for transporting information to and from mobile users on wireless communication links, and also include RF transceivers, or "remote antenna drivers" (RADs), which convert wireless frequency channels used in the wireless communication links to cable frequency channels used in the cable plant, and vice-versa. In such an application, the cable plant carries information between the microcell and a mobile communication system base station. Mobile wireless communication system microcells are often mounted atop telephone poles which support cables of the cable plant of a CATV network.

In a similar manner, the relay station 20A shown in Fig. 3 may be deployed at a microcell location to couple the wireless communication link 26 to the cable plant of a CATV network (represented by the physical communication link 90 of Fig. 3) to transport downstream information to one or more user stations 20B. As discussed above, the downstream link of a typical cable plant typically transports information carriers (frequency channels) having a carrier frequency in a range of from 54 MHz to 550 MHz. It should be appreciated, however, that while this frequency range is exemplary of typical CATV network downstream channels, a cable plant, and in particular the physical communication link 90 according to various embodiments of the invention, may support frequency channels in a different (e.g., broader) range of frequencies than those currently employed in conventional CATV networks.

Although the relay station 20A and the physical communication link 90 are described above for purposes of illustration in the context of a CATV network, it should be appreciated that the invention is not limited to this manner of implementation. In particular, the physical communication link 90 need not be associated with any particular type of communication system or existing network. Additionally, the relay station 20A need not be deployed at a particular location, such as at a mobile wireless communication microcell station.

As shown in the embodiment of Fig. 3, the relay station 20A also includes a second antenna 80 serving as a third "port" to receive upstream information from one or more user stations 20B on one or more wireless communication links 100. In various embodiments, the second antenna 80 may be a directional antenna, or may be a multi-directional or omni-directional antenna. Additionally, in one embodiment, the second antenna 80 may be significantly smaller and less obtrusive than the first antenna 60. In particular, while Fig. 3 shows the second antenna 80 as a small omni-directional antenna mounted above the relay station 20A, in one embodiment the antenna 80 may be implemented as a small "patch" array of antenna feeds (e.g., approximately one square foot in some cases) mounted to the relay station 20A. Such a patch array of antenna feeds may be constructed and arranged to have a variety of degrees of directionality to receive information carriers radiated from the user stations 20B. Examples of possible advantages of employing small unobtrusive antennas such as a patch array for the second antenna 80 of the relay station 20A are discussed further below, in connection with the user stations 20B.

In Fig. 3, as discussed above, each user station 20B is coupled to the physical communication link 90 at a first port 84, through which the user station 20B receives downstream information from the relay station 20A. Each user station 20B also includes an antenna 82 serving as a second "port" of the user station 20B, through which the user station transmits upstream information to the relay station 20A on the wireless communication link 100. Like the antenna 80 of the relay station 20A, the antenna 82 may be a directional, multi-directional, or omni-directional antenna. In particular, in one embodiment, the antenna 82 may be significantly smaller and less obtrusive than the directional antenna 60 of the relay station 20A. For example, the antenna 82 may be a small patch array of antenna feeds mounted to the user station 20B, as discussed above in connection with the relay station 20A. Each user station 20B may transmit respective upstream information to the relay station 20A on the wireless communication link 100 using a unique frequency channel, or may transmit its respective upstream information to the relay station 20A using the same frequency channel as one or more other users.

In particular, in one embodiment, one or more of the wireless communication links 100 shown in Fig. 3 may utilize one or more "spread spectrum" frequency channels to carry respective upstream information from each user station 20B. Spread spectrum transmission of information is a well-developed communication technology originally used for military applications, and is described in a number of texts such as, for example, chapter 11 of

Communication Systems Engineering, authored by John G. Proakis and Masoud Salehi and published by Prentice Hall, New Jersey, 1994, which text is hereby incorporated herein by reference.

The information carrying capacity of a given communication frequency channel is generally a function of the available channel bandwidth (or spectrum) and the power of the information carrier signal which is encoded with the information. Increasing either the available channel bandwidth or the carrier signal power generally increases the information carrying capacity of the channel. A particular information signal to be carried over a frequency channel by an information carrier generally requires a particular minimum channel capacity, which typically depends on the nature of the information signal. For example, faster and more dense information signals (e.g., signals having a higher information rate in bits/sec) generally require higher channel capacities (i.e., higher bandwidth channels and/or higher power carrier signals) to accurately transport the information.

"Spread spectrum" refers to the transmission of an information signal on a frequency channel having a significantly larger bandwidth than normally would be required for transmitting the information signal, given a particular carrier signal power. Spread spectrum signals were originally developed and used for military communications to hide an information signal by "artificially spreading" the bandwidth of the information signal (and hence the frequency channel), and then transmitting it on a very low power carrier signal, thus making it difficult for an unintended listener to detect its presence amidst background noise. In essence, by trading off carrier signal power for channel bandwidth (decreasing signal power while increasing bandwidth), the information carrying capacity of the channel is maintained.

In the spread spectrum communication technique, an information carrier encoded with an information signal at a transmitting source is spread in bandwidth by modulating the carrier with a code that has a higher bit rate (and hence requires a higher bandwidth) than the information signal. This code has the property of being "pseudorandom," and is commonly referred to as "pseudonoise" (PN). An information signal encoded on a carrier that is modulated by a PN code appears as random noise to a receiver that does not know the PN code; in particular, a spread spectrum receiver needs particular knowledge of the PN code to demodulate the carrier signal and recover the information signal. Hence, a spread spectrum communication channel typically employs a "matched pair" of PN code generators, one which modulates the information carrier on the transmitting end of the channel, and another which demodulates the carrier on the receiving end of the channel.

The PN code generated at the transmitting end of a spread spectrum communication channel may be used to modulate a phase of the information carrier. The resulting modulated carrier signal is called a direct-sequence (DS) spread spectrum signal. Alternatively, the available bandwidth of the spread spectrum channel may be divided into a number of frequency "slots," and the PN code may be used to modulate the frequency of the transmitted information carrier to randomly fall within a particular frequency "slot" of the channel at a particular time. The resulting signal in this case is referred to as a frequency-hopped (FH) spread spectrum signal. Direct-sequence and frequency-hopped signals are merely two examples of spread spectrum signals, and a number of other types of spread spectrum signals are known in the art.

One notable characteristic of either DS or FH spread spectrum signals is that several DS or FH spread spectrum signals may occupy the same channel bandwidth, provided that each signal has a unique PN code. In this manner, it is possible to have several users transmit messages simultaneously over the same spread spectrum channel. This type of communication, in which each user has its own distinct PN code, or "signature," for transmitting over a common channel is often referred to as "code division multiple access" (CDMA).

Before demodulation of CDMA spread spectrum signals, carrier signals at the receiving end of a spread spectrum channel from all of the transmitting users appear as additive interference or noise. The level of interference varies as a function of the number of the users on the channel at any given time. At the receiving end of the spread spectrum channel, a number of PN code generators are employed to demodulate the received carrier signals, each generator generating a PN code corresponding to the signature or PN code of a particular user. In this manner, the respective information signal associated with each user is recovered.

One significant advantage of CDMA is that a large number of users can be accommodated on a given spread spectrum channel, and it is relatively easy either to add new users or to decrease the number of users without reconfiguring the communication system, merely by employing greater or fewer PN code generator pairs. Also, it should be appreciated that while unique PN codes for each user enable simultaneous transmission over the same channel in CDMA, in some applications each user may transmit its respective information at any time relative to other users sharing the same channel. For example, time division multiple access (TDMA) techniques may be employed in conjunction with CDMA on a given spread

spectrum channel such that each user transmits (using its unique PN code) on the channel in one or more designated time slots.

In one embodiment of the hybrid cable/wireless communication system shown in Fig. 3, each user station 20B transmits upstream information on the wireless communication link 100 using the same spread spectrum frequency channel 102 by employing CDMA to carry the respective upstream information from each user station 20B. As discussed above, in CDMA, a unique PN code is associated with each user station 20B. At the relay station 20A, the spread spectrum channel 102 on the wireless communication link 100 is demodulated using each PN code to recover the respective information transmitted by each user station 20B.

Examples of frequency ranges suitable for the spread spectrum channel 102 on the wireless communication link 100 include, but are not limited to, the ISM (Industrial, Scientific, and Medical) frequency spectrum from 2.4 GHz to 2.485 GHz and including another band above approximately 5.8 GHz, and the U-NII (Unlicensed National Information Infrastructure) frequency spectrum from 5.15 GHz to 5.35 GHz and from 5.725 GHz to 5.825 GHz.. It should be appreciated that the bandwidths of these spectra generally are wider than the bandwidth typically associated with the upstream link of a two-way cable plant (approximately 25-37 MHz bandwidth). Accordingly, a spread spectrum channel 102 on the wireless communication link 100 may provide significantly more capacity for carrying upstream information from the user stations 20B than would the typical upstream link of a conventional two-way cable plant.

Another potential advantage of using a spread spectrum frequency channel on the wireless communication link 100 of the system shown in Fig. 3 is that the spread spectrum carrier signals may be transmitted at relatively low power (e.g., approximately 100 mW or less) using a small antenna 82 unobtrusively coupled to each user station 20B. The ability to use low power spread spectrum technology in conjunction with small unobtrusive antennas may be particularly desirable for residential applications in suburban areas, in which large antennas may be unappealing to users. Additionally, the low power spread spectrum carrier signals may be radiated multi-directionally or omni-directionally by the antenna 82, and as a result may be less vulnerable to line of sight obstructions between the user station antenna 82 and the relay station antenna 80. Such robustness against potential environmental interference provides yet another potential advantage which may render spread spectrum transmission particularly suitable, for example, in low-lying wooded areas and residential communities.

Fig. 4 is a diagram showing various components included in the relay station 20A and one exemplary user station 20B of the hybrid cable/wireless communication system shown in Fig. 3, according to one embodiment of the invention. It should be appreciated that the relay station and user station shown in Fig. 4 illustrate merely one possible implementation of a relay station and a user station according to the invention, and that the invention is not limited to the embodiment shown in Fig. 4. For example, as discussed above in connection with Fig. 3, the first port 134 of the relay station 20A, rather than being coupled to the wireless communication link 26, alternatively may be coupled to one or more physical communication links or a combination of wireless and physical communication links. In such alternative embodiments, it should be readily appreciated that some components of the relay station 20A shown in Fig. 4 may not be required.

In Fig. 4, the relay station 20A, like the subscriber station 20 shown in Fig. 2, includes a transceiver 64A coupled to the first port 134, and hence to the first antenna 60A via link 62A. The transceiver 64A is also coupled to an internal communication link 66A. The transceiver 64A converts the downstream and upstream frequency channels 28 and 30, respectively, of the wireless communication link 26 to corresponding downstream and upstream frequency channels 68A and 69A, respectively, which are transported on the internal communication link 66A. As discussed above, for other embodiments in which the first port 134 is coupled to one or more physical communication links instead of the wireless communication link 26, the antenna 60A, the link 62A, and the transceiver 64A may not be required, and the first port 134 may be coupled directly to the internal communication link 66A.

In one implementation of the relay station 20A shown in Fig. 4, the first antenna 60A is located in close proximity to the transceiver 64A so as to minimize any possible signal attenuation over the link 62A. In particular, the transceiver 64A may be coupled to the first antenna 60A using one or more low-loss connectors in the link 62A. For example, the link 62A may be one or more coaxial cables having a short length. Other low-loss methods of connecting the transceiver 64A to the first antenna 60A, such as employing one or more fiber optic cables, may be used to facilitate a greater separation between the first antenna 60A and the transceiver 64A in other implementations.

In one aspect of the embodiment of Fig. 4, the frequency channels 68A and 69A of the internal communication link 66A may have carrier frequencies in ranges approximately corresponding to those used in CATV networks. In particular, the upstream frequency channel 69A of the internal communication link 66A may be a cable frequency channel having a carrier

frequency in a range of from approximately 5 MHz to 40 MHz, and the downstream frequency channel 68A of the internal communication link may be a cable frequency channel having a carrier frequency in a range of from approximately 50 MHz to 1000 GHz. It should be appreciated that the foregoing exemplary frequency ranges are given for purposes of illustration only, and that the invention is not so limited.

In the embodiment of Fig. 4, the internal communication link 66A transports downstream and upstream information between the transceiver 64A and a splitter 122, which physically separates the frequency channels 68A and 69A. In one aspect of the embodiment of Fig. 4, the splitter 122 may be a diplexer. While a splitter generally splits the power of a given input signal between multiple outputs essentially irrespective of frequency, a diplexer typically includes filtering elements to separate signals based on frequency. In this manner, a diplexer employed as the splitter 122 individually directs the downstream and upstream carriers 68A and 69A based on their respective frequencies. In the embodiment of Fig. 4, an output of the splitter/diplexer 122 serves as the second port 132 of the relay station 20A, from which the downstream frequency channel 68A is transported on the physical communication link 90 to the user stations 20B.

It should be appreciated that although the internal communication link 66A is shown as a single bi-directional communication link in the embodiment of Fig. 4, the invention is not limited to such an implementation. For example, in one embodiment, the internal communication link 66A of the relay station 20A may include two or more discrete conductors, wherein the downstream frequency channel 68A is physically separated from the upstream frequency channel 69A as the channels are respectively transported from and to the transceiver 64A. In such an embodiment, the splitter/diplexer 122 may not be necessary, and the second port 132 of the relay station 20A would be served directly by an output of the transceiver 64A which outputs the downstream frequency channel 68A.

In the embodiment of Fig. 4, the relay station 20A also includes a converter 110 coupled to the second antenna 80 to receive upstream information from the user station 20B on the wireless communication link 100. The converter 110 converts the wireless frequency channel carrying the upstream information on the wireless link 100 to the upstream frequency channel 69A, which is output by the converter to the splitter/diplexer 122. The splitter/diplexer 122 directs the upstream frequency channel 69A to the internal communication link 66A, which transports the upstream frequency channel 69A to the transceiver 64A. As discussed above, in an alternate implementation of the relay station 20A in which the internal

communication link 66A includes two or more discrete conductors, for example, the splitter/diplexer 122 may not be necessary, and an output of the converter 110 outputting the frequency channel 69A may be coupled directly to the transceiver 64A.

In one aspect of the embodiment of Fig. 4, the converter 110 may be a spread spectrum-to-cable converter, which receives upstream information on a spread spectrum frequency channel 102 of the wireless communication link 100 and converts the spread spectrum frequency channel to a cable frequency channel for upstream transmission to the transceiver 64A. In this aspect, the converter 110 may be designed to accommodate CDMA spread spectrum information transmission, in which each user station 20B transmits upstream information modulated by a unique signature (PN code) on the same spread spectrum frequency channel 102 over the wireless link 100. In particular, the converter 110 may be equipped with one or more PN code generators to demodulate the respective upstream information transmitted from each user station 20B.

Fig. 4 also shows that, in one embodiment, the user station 20B may include premises equipment 74A coupled to a user station modem 70A via link 72A. The premises equipment 74A and the user station modem 70A may be similar to those described above in connection with the subscriber station 20 shown in Fig. 2. In particular, the premises equipment 74A may include, for example, one or more personal computers, video monitors, telephones, cameras, microphones, user interfaces, and the like.

As show in Fig. 4, the user station modem 70A is coupled to a user station internal communication link 116 which transports the downstream frequency channel 68A and the upstream frequency channel 69A to and from the modem 70A, respectively. In one aspect of this embodiment, the modem 70A may be capable of either TDMA and CDMA modulation and demodulation techniques. One example of a user station modem 70A suitable for purposes of the invention is given by the Model CONX modem, manufactured by Integrity, Inc., of Richmond, Virginia. It should be appreciated, however, that the invention is not limited to this specific type of modem, and that other types of modems may be employed in other embodiments.

In the embodiment of Fig. 4, the link 116 is coupled to a splitter/diplexer 114 having an input serving as a first port 84 of the user station 20B and coupled to the physical communication link 90. The splitter/diplexer 114 may function similarly to that of the splitter/diplexer 122. It should be appreciated that while the user station internal communication link 116 is shown in Fig. 4 as a single bi-directional communication link

transporting both the upstream frequency channel 69A and the downstream frequency channel 68A to and from the splitter/diplexer 114, in another embodiment of the invention, the link 116 may include two or more discrete conductors which maintain the frequency channels 68A and 69A physically separate on the link 116. In this embodiment, the splitter/diplexer 114 may not be necessary, and the first port 84 of the user station 20B would be provided directly by an input of the modem 70A which receives the downstream frequency channel 68A.

As shown in Fig. 4, the user station 20B may also include a converter 112 coupled to the antenna 82 to transmit upstream information from the user station 20B on the wireless communication link 100. The converter 112 converts the upstream frequency channel 69A output from the splitter/diplexer 114 to a wireless frequency channel carrying the upstream information on the wireless link 100. As discussed above, in an alternate implementation of the user station 20B, in which the link 116 includes two or more discrete conductors, for example, the splitter/diplexer 114 may not be necessary, and an output of the modem 70A outputting the frequency channel 69A may be coupled directly to an input of the converter 112.

In one aspect of the embodiment of Fig. 4, the converter 112 may be a cable-to-spread spectrum converter, which receives upstream information from the modem 70A on a cable frequency channel and converts the cable frequency channel to a spread spectrum frequency channel 102 for upstream transmission on the wireless communication link 100. In this aspect, the converter 110 of the relay station 20A would be a spread spectrum-to-cable converter, as discussed above. Additionally, the converter 112 of the user station 20B may be designed to accommodate CDMA spread spectrum information transmission, as discussed above in connection with the relay station converter 110. In particular, the user station converter 112 may be equipped with a unique PN code generator to modulate the upstream information transmitted from the user station 20B.

Fig. 5 is a diagram showing various components included in the relay station 20A and one exemplary user station 20B of the hybrid cable/wireless communication system shown in Fig. 3, according to another embodiment of the invention. As with the embodiment of Fig. 4, it should be appreciated that the relay station and user station shown in Fig. 5 illustrate merely one possible implementation of a relay station and a user station according to the invention and that the invention is not limited to the embodiment shown in Fig. 5. For example, as discussed above in connection with Fig. 3, the first port 134 of the relay station 20A of Fig. 5, rather than being coupled to the wireless communication link 26, alternatively may be coupled to one or more physical communication links or a combination of wireless and physical communication

links. In such alternative embodiments, it should be readily appreciated that some components of the relay station 20A shown in Fig. 5 may not be required.

Like the relay station 20A shown in Fig. 4, the relay station 20A of Fig. 5 includes an antenna 60A coupled to the first port 134 via link 62A. The relay station 20A of Fig. 5 also includes a transceiver 64A coupled to the first port 134. As discussed above, for other embodiments in which the first port 134 is coupled to one or more physical communication links, the antenna 60A, the link 62A, and the transceiver 64A may not be required.

In the embodiment of Fig. 5, the downstream frequency channel 68A output via the second port 132 of the relay station 20A over the physical communication link 90 is coupled directly to an input of demodulator 70B in the user station 20B. The input of the demodulator 70B serves as the first port 84 of the user station 20B. The demodulator 70B demodulates the downstream frequency channel 68A and outputs downstream information to the premises equipment 74A via the link 72A. In one aspect of this embodiment, the demodulator may be capable of either TDMA or CDMA demodulation techniques. Additionally, in one aspect of the embodiment of Fig. 5, the frequency channel 68A is a cable frequency channel, and the demodulator is designed so as to demodulate cable frequency channels. One example of a demodulator 70B suitable for purposes of the invention is given by the Model AC-3 demodulator manufactured by Sample Rate Systems, Inc. It should be appreciated, however, that the invention is not limited to this specific type of demodulator, and that other types of demodulators may be employed in other embodiments.

As shown in Fig. 5, the premises equipment 74A outputs upstream information to a transmitter 150 coupled to the antenna 82 to transmit upstream information from the user station 20B on the wireless communication link 100. In one aspect of the embodiment of Fig. 5, the transmitter 150 may be a spread spectrum transmitter which receives upstream information from the premises equipment 74A and encodes the upstream information on one or more spread spectrum frequency channels 102 for upstream transmission on the wireless communication link 100. As discussed above, a spread spectrum transmitter may be designed to accommodate CDMA spread spectrum information transmission and may be equipped with a unique PN code generator to modulate the upstream information transmitted from the user station 20B. One example of a transmitter 150 capable of spread spectrum transmission and suitable for purposes of the invention is given by the Harris Prism Spread Spectrum 2-way Radio Model No. HFA3424, manufactured by Harris Corporation of Melbourne, Florida. It

should be appreciated, however, that the invention is not limited to this specific type of transmitter, and that other types of transmitters may be employed in other embodiments.

In the embodiment of Fig. 5, the relay station 20A includes a receiver 152 coupled to the second antenna 80 to receive upstream information from the user station 20B on the wireless communication link 100. In one aspect of the embodiment of Fig. 5, the receiver 152 may be a spread spectrum receiver which receives upstream information on one or more spread spectrum frequency channels 102 of the wireless communication link 100. In this aspect the receiver 152 may be designed to accommodate CDMA spread spectrum information transmission in which each user station 20B transmits upstream information modulated by a unique signature (PN code) on the same spread spectrum frequency channel 102 over the wireless link 100. In particular, the receiver 152 may be equipped with one or more PN code generators to demodulate the respective upstream information transmitted from each user station 20B. One example of a receiver 152 capable of receiving spread spectrum information and suitable for purposes of the invention is given by the Harris Prism Spread Spectrum 2-way Radio Model No. HFA3424, as discussed above. It should be appreciated, however, that the invention is not limited to this specific type of receiver and that other types of receivers may be employed in other embodiments.

The receiver 152 outputs the upstream information to a modulator 70C which encodes the upstream information onto the upstream information carrier 69A. Like the demodulator 70B, in one aspect of this embodiment the modulator 70C may be capable of either TDMA or CDMA modulation techniques. Additionally, in one aspect of the embodiment of Fig. 5, the modulator modulates a cable frequency channel with the upstream information (i.e., the upstream frequency channel 69A is a cable frequency channel). One example of a modulator 70C suitable for purposes of the invention is given by the Model RM212-D RF Modulator manufactured by UDC. It should be appreciated, however, that the invention is not limited to this specific type of modulator and that other types of modulators may be employed in other embodiments.

It should also be appreciated that in other embodiments of the invention based on the embodiments illustrated in Figs. 4 and 5, the relay station 20A of Fig. 4 may be used in conjunction with one or more user stations 20B of Fig. 5. Likewise, the relay station 20A of Fig. 5 may be used with one or more user stations 20B of Fig. 4. In general, a relay station according to either of Figs. 4 or 5 may be used with a number of different user stations, some

of which are similar to the user station shown in Fig. 4 and others which are similar to the user station shown in Fig. 5.

In view of the foregoing, it should also be appreciated that, according to one embodiment of the invention, the spread spectrum-to-cable converter 110 shown in the relay station of Fig. 4 may include a spread spectrum receiver 152 and a cable modulator 70C similar to those shown in the relay station of Fig. 5. Similarly, according to one embodiment of the invention, the cable-to-spread spectrum converter 112 shown in the user station of Fig. 4 may include a cable demodulator 70B and a spread spectrum transmitter 150 similar to those shown in the user station of Fig. 5.

In sum, hybrid cable/wireless communication systems and methods according to various embodiments of the invention incorporate features of both wireless communication links and physical communication links. In particular, the concepts discussed herein relating to hybrid cable/wireless communication systems and methods according to one embodiment of the invention permit existing networks of physical communication links used in primarily one-way communication systems to be integrated with a high-capacity two-way wireless communication system to conveniently and inexpensively provide a variety of two-way information services to a number of users.

For example, a hybrid cable/wireless communication system according to one embodiment of the invention may couple an existing one-way CATV network cable plant (or two-way cable plant) to a high-capacity two-way communication system and provide for two-way user communications by adding one or more high-capacity wireless links to transport upstream information from the users. In this manner, hybrid communication systems according to some embodiments of the invention may be particularly well-suited for locations such as urban and suburban areas, or residential areas in general, in which one-way cable plants are extensively deployed. In particular, a hybrid system according to one embodiment of the invention employing low power spread spectrum upstream transmission from users may be particularly appealing for residential applications, in that the system is both environmentally robust (e.g., with respect to line of sight issues) and aesthetically pleasing, requiring only a small unobtrusive antenna for the user upstream wireless link.

The above-discussed aspects of the present invention can be implemented in any of numerous ways, as the invention is not limited to any particular manner of implementation. For example, in one embodiment, various aspects of a hybrid cable/wireless communication system according to the invention were developed in the context of expanding a particular two-

way broadband wireless communication system (as described in connection with Fig. 1) by employing a relay station to couple the wireless communication system to one or more physical communication links, such as the cable plant of a CATV network. However, it should be appreciated that according to other embodiments of the invention, a relay station may couple wireless and/or physical communication links to and from a signal source (or headend) of any number and variety of communication systems to one or more users.

Having thus described certain embodiments of the present invention, various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only, and is not intended to be limiting. The invention is limited only as defined in the following claims and the equivalents thereof.

What is claimed is:

CLAIMS

1. A two-way communication method, comprising acts of:

transporting first information to at least one user on at least one physical communication link coupled to the at least one user; and

transporting second information from the at least one user on at least one wireless communication link coupled to the at least one user.

2. The method of claim 1, wherein the act of transporting first information includes an act of transporting the first information to the at least one user from a relay station only on physical communication links.

3. The method of claim 1, wherein the act of transporting second information includes an act of transporting the second information from the at least one user to a relay station only on wireless communication links.

4. The method of claim 3, wherein the act of transporting first information includes an act of transporting the first information to the at least one user from the relay station only on physical communication links.

5. The method of claim 4, further including an act of transporting the first information to the relay station and transporting the second information from the relay station on at least one two-way wireless communication link.

6. The method of claim 5, wherein the act of transporting the first information to the relay station and transporting the second information from the relay station includes acts of:

transporting the first information using a first MMDS frequency channel; and

transporting the second information using a second MMDS frequency channel.

7. The method of claim 1, wherein the act of transporting first information on at least one physical communication link includes an act of transporting the first information on at least a portion of a cable plant.

8. The method of claim 1, wherein the act of transporting first information includes an act of transporting the first information using at least one cable frequency channel of the at least one physical communication link.

9. The method of claim 1, wherein the act of transporting second information includes an act of transporting the second information using at least one spread spectrum encoded channel of the at least one wireless communication link.

10. The method of claim 9, wherein the act of transporting the second information using at least one spread spectrum encoded channel includes an act of transporting the second information using a carrier frequency in the ISM frequency range.

11. The method of claim 9, wherein the act of transporting the second information using at least one spread spectrum encoded channel includes an act of transporting the second information using a carrier frequency in the U-NII frequency range.

12. The method of claim 9, wherein:

the at least one user includes a plurality of users; and

the act of transporting second information includes an act of transporting respective information from each user of the plurality of users on the same spread spectrum encoded channel of the at least one wireless communication link.

13. A method of transporting data between a relay station and at least one fixed user, comprising acts of:

receiving at the relay station at least one first wireless frequency channel over the air, the at least one first wireless frequency channel carrying first data;

converting the at least one first wireless frequency channel to at least one first frequency channel carrying the first data;

transmitting the at least one first frequency channel from the relay station to the at least one fixed user over at least one physical communication link;

transmitting at least one second wireless frequency channel over the air from the at least one fixed user to the relay station, the at least one second wireless frequency channel carrying second data;

receiving the at least one second wireless frequency channel over the air at the relay station;

converting the at least one second wireless frequency channel to at least one third wireless frequency channel carrying the second data; and

transmitting from the relay station the at least one third wireless frequency channel over the air.

14. The method of claim 13, wherein:

the act of receiving at the relay station at least one first wireless frequency channel over the air includes an act of receiving at the relay station a first MMDS frequency channel over the air, the first MMDS frequency channel carrying the first data;

the act of converting the at least one second wireless frequency channel to at least one third wireless frequency channel carrying the second data includes an act of converting the at least one second wireless frequency channel to a second MMDS frequency channel carrying the second data; and

the act of transmitting from the relay station the at least one third wireless frequency channel over the air includes an act of transmitting from the relay station the second MMDS frequency channel over the air, the second MMDS frequency channel carrying the second data.

15. The method of claim 13, wherein:

the act of converting the at least one first wireless frequency channel to at least one first frequency channel carrying the first data includes an act of converting the at least one first wireless frequency channel to a cable frequency channel carrying the first data; and

the act of transmitting the at least one first frequency channel from the relay station to the at least one fixed user over at least one physical communication link includes an act of transmitting the cable frequency channel from the relay station to the at least one fixed user over the at least one physical communication link.

16. The method of claim 13, wherein:

the act of transmitting at least one second wireless frequency channel over the air from the at least one fixed user to the relay station includes an act of transmitting at least one spread spectrum encoded frequency channel over the air from the at least one fixed user to the relay station, the at least one spread spectrum encoded frequency channel carrying the second data;

the act of receiving the at least one second wireless frequency channel over the air at the relay station includes an act of receiving the at least one spread spectrum encoded frequency channel over the air at the relay station; and

the act of converting the at least one second wireless frequency channel to at least one third wireless frequency channel carrying the second data includes an act of converting the at least one spread spectrum encoded frequency channel to at least one third wireless frequency channel carrying the second data.

17. The method of claim 13, wherein:

the act of receiving at the relay station at least one first wireless frequency channel over the air includes an act of receiving at the relay station a first MMDS frequency channel over the air, the first MMDS frequency channel carrying the first data;

the act of converting the at least one first wireless frequency channel to at least one first frequency channel carrying the first data includes an act of converting the first MMDS frequency channel to a cable frequency channel carrying the first data;

the act of transmitting the at least one first frequency channel from the relay station to the at least one fixed user over at least one physical communication link includes an act of transmitting the cable frequency channel from the relay station to the at least one fixed user over the at least one physical communication link;

the act of transmitting at least one second wireless frequency channel over the air from the at least one fixed user to the relay station includes an act of transmitting at least one spread spectrum encoded frequency channel over the air from the at least one fixed user to the relay station, the at least one spread spectrum encoded frequency channel carrying the second data;

the act of receiving the at least one second wireless frequency channel over the air at the relay station includes an act of receiving the at least one spread spectrum encoded frequency channel over the air at the relay station;

the act of converting the at least one second wireless frequency channel to at least one third wireless frequency channel carrying the second data includes an act of converting the at least one spread spectrum encoded frequency channel to a second MMDS frequency channel carrying the second data; and

the act of transmitting from the relay station the at least one third wireless frequency channel over the air includes an act of transmitting from the relay station the second MMDS frequency channel over the air.

18. The method of claim 13, wherein the act of transmitting the at least one first frequency channel from the relay station includes an act of transmitting the at least one second frequency channel on at least a portion of a cable plant.

19. The method of claim 13, wherein the act of transmitting at least one second wireless frequency channel includes an act of transmitting at least one second wireless frequency channel having a carrier frequency in the ISM frequency range.

20. The method of claim 13, wherein the act of transmitting at least one second wireless frequency channel includes an act of transmitting at least one second wireless frequency channel having a carrier frequency in the U-NII frequency range.

21. The method of claim 13, wherein:

the at least one fixed user includes a plurality of fixed users; and

the act of transmitting at least one second wireless frequency channel includes an act of transmitting to the relay station a same second wireless frequency channel over the air from each fixed user of the plurality of fixed users, the same second wireless frequency channel carrying respective data from each fixed user.

22. The method of claim 21, wherein the act of converting the at least one second wireless frequency channel to at least one third wireless frequency channel includes an act of converting the same second wireless frequency channel to the at least one third wireless frequency channel, the at least one third wireless frequency channel carrying the respective data from each fixed user.

23. The method of claim 21, wherein the act of transmitting a same second wireless frequency channel over the air from each fixed user of the plurality of fixed users to the relay station includes an act of transmitting to the relay station a same spread spectrum encoded frequency channel over the air from each fixed user of the plurality of fixed users, the same spread spectrum encoded frequency channel carrying the respective data from each fixed user.

24. The method of claim 23, wherein the act of converting the at least one second wireless frequency channel to at least one third wireless frequency channel includes an act of converting the same spread spectrum encoded frequency channel to the at least one third wireless frequency channel, the at least one third wireless frequency channel carrying the respective data from each fixed user.

25. An information station including premises equipment to be used by a user, the premises equipment receiving first information and outputting second information, the information station comprising:

a first port, coupled to at least one physical communication link, through which to receive the first information transmitted to the information station on the at least one physical communication link; and

a second port, coupled to at least one wireless communication link, through which to transmit the second information from the information station on the at least one wireless communication link.

26. The information station of claim 25, wherein the at least one physical communication link includes at least a portion of a cable plant.

27. The information station of claim 25, wherein the information station receives the first information through the first port on at least one cable frequency channel of the at least one physical communication link.

28. The information station of claim 25, wherein the information station transmits the second information through the second port on at least one spread spectrum encoded frequency channel of the at least one wireless communication link.

29. The information station of claim 25, further including at least one transmitter, coupled to the premises equipment and to the second port, to receive the second information output from the premises equipment and to transmit at least one wireless communication channel carrying the second information on the at least one wireless communication link.

30. The information station of claim 29, wherein:

the at least one wireless communication channel includes at least one spread spectrum encoded frequency channel; and

the at least one transmitter includes at least one spread spectrum transmitter.

31. The information station of claim 29, further including at least one demodulator, coupled to the premises equipment and to the first port, to receive a first frequency channel carrying the first information on the at least one physical communication link, the demodulator demodulating the first frequency channel so as to output the first information to the premises equipment.

32. The information station of claim 31, wherein:

the first frequency channel is a TDMA encoded frequency channel; and

the at least one demodulator is capable of demodulating the TDMA encoded frequency channel.

33. The information station of claim 31, wherein:

the first frequency channel is a CDMA encoded frequency channel; and

the at least one demodulator is capable of demodulating the CDMA encoded frequency channel.

34. The information station of claim 31, wherein:

the first frequency channel is a cable frequency channel; and

the at least one wireless communication channel includes at least one spread spectrum encoded frequency channel.

35. The information station of claim 25, further including at least one modem, coupled to the premises equipment and to the first port, to receive a first frequency channel carrying the first information on the at least one physical communication link and to demodulate the first frequency channel so as to output the first information to the premises equipment, the at least one modem also receiving the second information output from the premises equipment and modulating a second frequency channel to carry the second information.

36. The information station of claim 35, wherein:

the first frequency channel is a first TDMA encoded frequency channel; and

the at least one modem is capable of demodulating the first TDMA encoded frequency channel.

37. The information station of claim 36, wherein:

the second frequency channel is a second TDMA encoded frequency channel; and

the at least one modem is capable of modulating the second TDMA encoded frequency channel.

38. The information station of claim 35, wherein:

the first frequency channel is a first CDMA encoded frequency channel; and

the at least one modem is capable of demodulating the first CDMA encoded frequency channel.

39. The information station of claim 38, wherein:

the second frequency channel is a second CDMA encoded frequency channel; and

the at least one modem is capable of modulating the second CDMA encoded frequency channel.

40. The information station of claim 35, further including at least one converter, coupled to the at least one modem and to the second port, to receive the modulated second frequency channel and to convert the modulated second frequency channel to at least one wireless frequency channel carrying the second information, the at least one converter transmitting the at least one wireless frequency channel on the at least one wireless communication link.

41. The information station of claim 40, wherein:

the modulated second frequency channel is a modulated cable frequency channel;

the at least one wireless frequency channel includes at least one spread spectrum encoded frequency channel; and

the at least one converter includes at least one cable-to-spread spectrum converter.

42. A relay station, comprising:

a first port, coupled to at least one two-way communication link, through which to receive first information and to transmit second information on the at least one two-way communication link;

a second port, coupled to at least one user physical communication link, through which to transmit the first information on the at least one user physical communication link; and

a third port, coupled to at least one user wireless communication link, through which to receive the second information on the at least one user wireless communication link.

43. The relay station of claim 42, wherein the at least one two-way communication link includes at least one of a wireless communication link and a physical communication link.

44. The relay station of claim 42, wherein the at least one two-way communication link includes at least one two-way physical communication link.

45. The relay station of claim 42, wherein the at least one two-way communication link includes at least one two-way wireless communication link.

46. The relay station of claim 45, wherein:

the first port includes a directional antenna; and

the third port includes a nondirectional antenna.

47. The relay station of claim 45, wherein:

the relay station receives the first information through the first port on a first MMDS frequency channel of the at least one two-way wireless communication link; and

the relay station transmits the second information through the first port on a second MMDS frequency channel of the at least one two-way wireless communication link.

48. The relay station of claim 42, wherein the at least one user physical communication link includes at least a portion of a cable plant.

49. The relay station of claim 42, wherein the relay station transmits the first information through the second port on at least one cable frequency channel of the at least one user physical communication link.

50. The relay station of claim 42, wherein the relay station receives the second information through the third port on at least one spread spectrum encoded frequency channel of the at least one user wireless communication link.

51. The relay station of claim 50, wherein:

the at least one two-way communication link includes at least one two-way wireless communication link;

the relay station receives the first information through the first port on a first MMDS frequency channel of the at least one two-way wireless communication link;

the relay station transmits the second information through the first port on a second MMDS frequency channel of the at least one two-way wireless communication link; and

the relay station transmits the first information through the second port on at least one cable frequency channel of the at least one user physical communication link.

52. The relay station of claim 42, further including at least one receiver, coupled to the third port, to receive at least one wireless communication channel carrying the second information on the at least one user wireless communication link and to output the second information.

53. The relay station of claim 52, wherein:

the at least one wireless communication channel includes at least one spread spectrum encoded wireless communication channel; and

the at least one receiver includes at least one spread spectrum receiver.

54. The relay station of claim 53, further including at least one modulator, coupled to the at least one receiver, to receive the second information output from the at least one receiver and to modulate at least one modulator frequency channel to carry the second information.

55. The relay station of claim 54, further including at least one transceiver, coupled to the first port to receive the first information and to transmit the second information on the at least one two-way communication link, coupled to the second port to transmit the first information on the at least one physical communication link, and coupled to the at least one

modulator to receive the at least one modulator frequency channel, the at least one transceiver converting a first frequency channel carrying the first information received at the first port to a user frequency channel carrying the first information on the at least one physical communication link, and converting the at least one modulator frequency channel to a second frequency channel carrying the second information transmitted at the first port.

56. The relay station of claim 42, further including at least one converter, coupled to the third port to receive the second information on at least one wireless frequency channel of the at least one user wireless communication link, the at least one converter converting the at least one wireless frequency channel to at least one converted frequency channel carrying the second information.

57. The relay station of claim 56, wherein:

the at least one wireless frequency channel includes at least one spread spectrum encoded frequency channel;

the at least one converted frequency channel includes at least one cable frequency channel; and

the at least one converter includes at least one spread spectrum-to-cable converter.

58. The relay station of claim 56, further including at least one transceiver, coupled to the first port to receive the first information and to transmit the second information on the at least one two-way communication link, coupled to the second port to transmit the first information on the at least one physical communication link, and coupled to the at least one converter to receive the at least one converted frequency channel, the at least one transceiver converting a first frequency channel carrying the first information received at the first port to a user frequency channel carrying the first information on the at least one physical communication link, and converting the at least one converted frequency channel to a second frequency channel carrying the second information transmitted at the first port.

59. A system, comprising:

a relay station to transport information; and

at least one information station including premises equipment to be used by a user, the premises equipment receiving first information and outputting second information, the at least

one information station coupled to the relay station to receive the first information from the relay station on at least one user physical communication link and to transmit the second information to the relay station on at least one user wireless communication link.

60. The system of claim 59, wherein the at least one user physical communication link includes at least a portion of a cable plant.

61. The system of claim 59, wherein the at least one information station transmits the second information to the relay station on at least one spread spectrum encoded frequency channel of the at least one user wireless communication link.

62. The system of claim 59, wherein:

the at least one information station includes a plurality of information stations; and

each information station of the plurality of information stations transmits respective second information to the relay station on a same user wireless communication link.

63. The system of claim 62, wherein the same user wireless communication link includes a spread spectrum encoded frequency channel, the spread spectrum encoded frequency channel carrying the respective second information transmitted by each information station.

64. The system of claim 59, wherein the relay station includes:

a first port, coupled to at least one two-way communication link, through which to receive the first information and to transmit the second information on the at least one two-way communication link;

a second port, coupled to the at least one user physical communication link, through which to transmit the first information on the at least one user physical communication link; and

a third port, coupled to the at least one user wireless communication link, through which to receive the second information on the at least one user wireless communication link.

65. The system of claim 64, wherein the at least one two-way communication link includes at least one two-way wireless communication link.

66. The system of claim 65, wherein:

the relay station receives the first information through the first port on a first MMDS frequency channel of the at least one two-way wireless communication link;

the relay station transmits the second information through the first port on a second MMDS frequency channel of the at least one two-way wireless communication link;

the relay station transmits the first information through the second port on at least one cable frequency channel of the at least one user physical communication link; and

the relay station receives the second information through the third port on at least one spread spectrum encoded frequency channel of the at least one user wireless communication link.

67. The system of claim 64, wherein the relay station includes:

a transceiver coupled to the first port to receive the first information and to transmit the second information, and coupled to the second port to transmit the first information on the at least one physical communication link; and

a first converter, coupled to the third port to receive the second information on the at least one user wireless communication link, and coupled to the transceiver to transmit the second information to the transceiver.

68. The system of claim 67, wherein:

the first converter receives the second information on a spread spectrum encoded frequency channel of the at least one user wireless communication link; and

the first converter transmits the second information to the transceiver on a cable frequency channel.

69. The system of claim 64, wherein the relay station includes:

a transceiver coupled to the first port to receive the first information and to transmit the second information, and coupled to the second port to transmit the first information on the at least one physical communication link;

a receiver, coupled to the third port to receive the second information on the at least one user wireless communication link; and

a modulator, coupled to the transceiver and to the receiver, to receive the second information from the receiver, to modulate a frequency carrier to carry the second information, and to output the frequency carrier to the transceiver.

70. The system of claim 69, wherein the receiver is a spread spectrum receiver.

71. The system of claim 68, wherein the at least one information station includes:

at least one modem coupled to the premises equipment and to the at least one user physical communication link to demodulate a first frequency channel carrying the first information on the at least one user physical communication link, and to modulate a second frequency channel with the second information; and

a second converter coupled to the at least one modem and to the at least one user wireless communication link to receive the second frequency channel and to transmit a third frequency channel carrying the second information on the at least one user wireless communication link.

72. The system of claim 71, wherein:

the second frequency channel is a cable frequency channel;

the third frequency channel is a spread spectrum encoded frequency channel; and

the second converter is a cable-to-spread spectrum converter.

73. The system of claim 69, wherein the at least one information station includes:

at least one demodulator coupled to the premises equipment and to the at least one user physical communication link to demodulate a first frequency channel carrying the first information on the at least one user physical communication link; and

a transmitter coupled to the premises equipment to transmit a second frequency channel carrying the second information on the at least one user wireless communication link.

74. The system of claim 73, wherein:

the first frequency channel is a cable frequency channel; and

the second frequency channel is a spread spectrum frequency channel.

75. A hybrid cable/wireless communication system, comprising:

a base station to transmit downstream information and to receive upstream information on at least one two-way broadband wireless communication link;

at least one fixed subscriber station, coupled to the at least one two-way broadband wireless communication link, to transmit at least some of the upstream information to the base station and to receive at least some of the downstream information from the base station; and

at least one relay station, including:

a first port, coupled to the at least one two-way wireless communication link, through which to receive at least some of the downstream information from the base station and to transmit at least some of the upstream information to the base station;

a second port, coupled to at least one user physical communication link, through which to transmit the at least some of the downstream information on the at least one user physical communication link; and

a third port, coupled to at least one user wireless communication link, through which to receive the at least some of the upstream information on the at least one user wireless communication link.

76. The system of claim 75, further including a switching infrastructure, coupled to the base station, to transmit the downstream information to the base station and to receive the upstream information from the base station in a predetermined manner.

77. The system of claim 75, wherein the at least one user physical communication link includes at least a portion of a cable plant.

78. The system of claim 75, wherein:

the at least one two-way wireless communication link includes:

at least one first wireless frequency channel to carry the downstream information; and

at least one second wireless frequency channel to carry the upstream information;

the at least one user physical communication link includes at least one cable frequency channel to carry the at least some of the downstream information; and

the at least one user wireless communication link includes at least one spread spectrum encoded frequency channel to carry the at least some of the upstream information.

79. The system of claim 78, wherein the at least one first and second wireless frequency channels are at least one first and second MMDS frequency channels, respectively.

80. The system of claim 75, wherein the at least one two-way broadband wireless communication link has an information carrying capacity of at least 10 Megabits per second for both the downstream information and the upstream information.

81. The system of claim 75, further including at least one user station, coupled to the at least one relay station, to receive the at least some of the downstream information from the at least one relay station on the at least one user physical communication link and to transmit the at least some of the upstream information to the at least one relay station on the at least one user wireless communication link.

82. The system of claim 81, wherein the at least one user wireless communication link includes at least one spread spectrum encoded frequency channel to carry the at least some of the upstream information.

83. The system of claim 82, wherein:

the at least one two-way wireless communication link includes:

at least one first wireless frequency channel to carry the downstream information; and

at least one second wireless frequency channel to carry the upstream information; and

the at least one user physical communication link includes at least one cable frequency channel to carry the at least some of the downstream information.

84. The system of claim 83, wherein the at least one first and second wireless frequency channels are at least one first and second MMDS frequency channels, respectively.

85. The system of claim 81, wherein:

the at least one user station includes a plurality of user stations; and

each user station of the plurality of user stations transmits respective information to the at least one relay station on a same user wireless communication link.

86. The system of claim 85, wherein the same user wireless communication link includes a spread spectrum encoded frequency channel, the spread spectrum encoded frequency channel carrying the respective information transmitted by each user station.

87. A spread spectrum-to-cable converter, comprising:

a spread spectrum receiver to receive at least one spread spectrum encoded frequency channel, the at least one spread spectrum encoded frequency channel carrying information, the spread spectrum receiver decoding the at least one spread spectrum encoded frequency channel and outputting the information; and

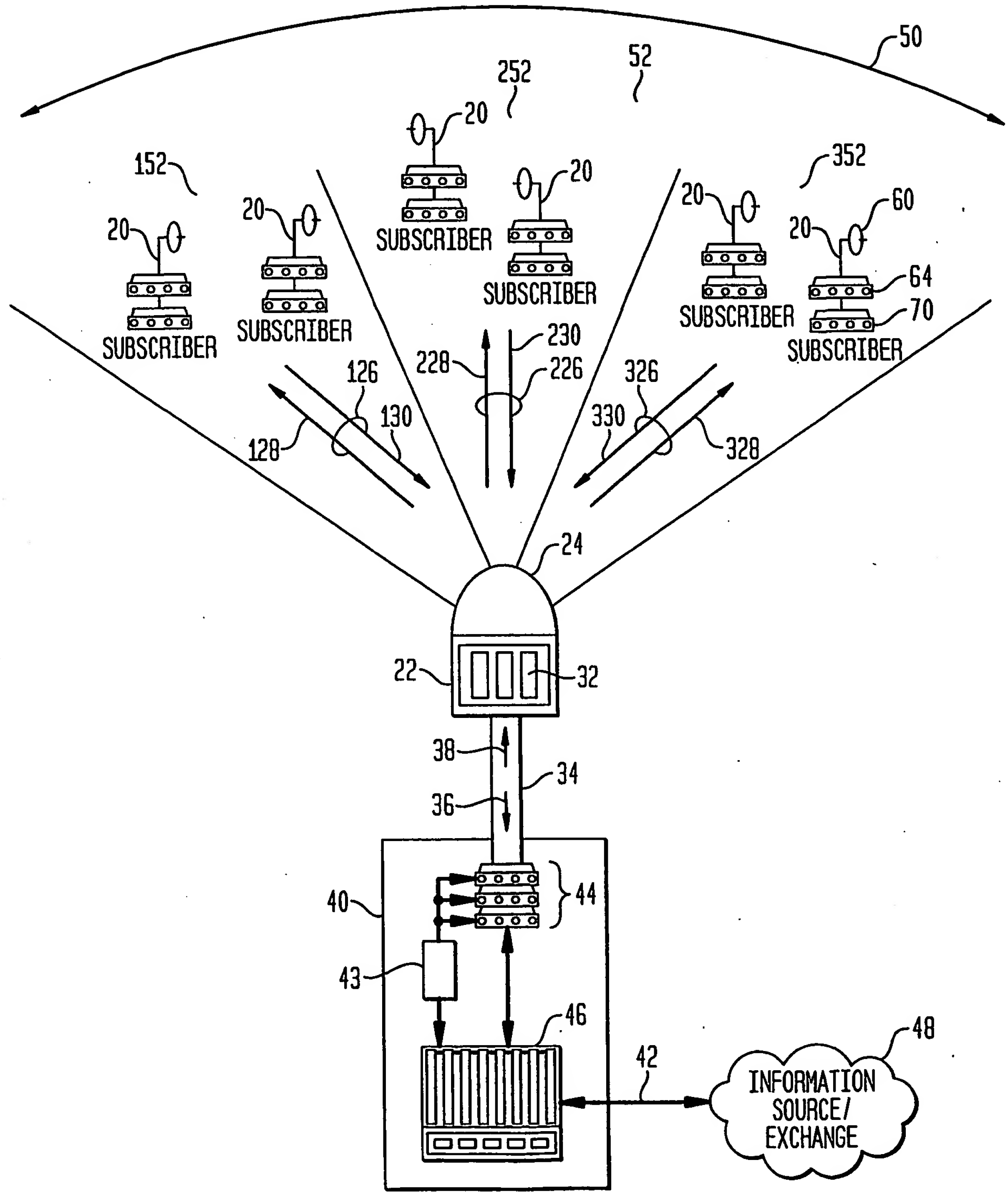
a cable modulator, coupled to the spread spectrum receiver, to receive the information output by the spread spectrum receiver and to modulate at least one cable frequency channel with the information, the cable modulator outputting the at least one modulated cable frequency channel.

88. A cable-to-spread spectrum converter, comprising:

a cable demodulator to receive at least one cable frequency channel carrying information, the cable demodulator demodulating the at least one cable frequency channel and outputting the information; and

a spread spectrum transmitter, coupled to the cable demodulator, to receive the information output by the cable demodulator and to encode at least one spread spectrum encoded frequency channel with the information, the spread spectrum transmitter transmitting the encoded at least one spread spectrum encoded frequency channel.

FIG. 1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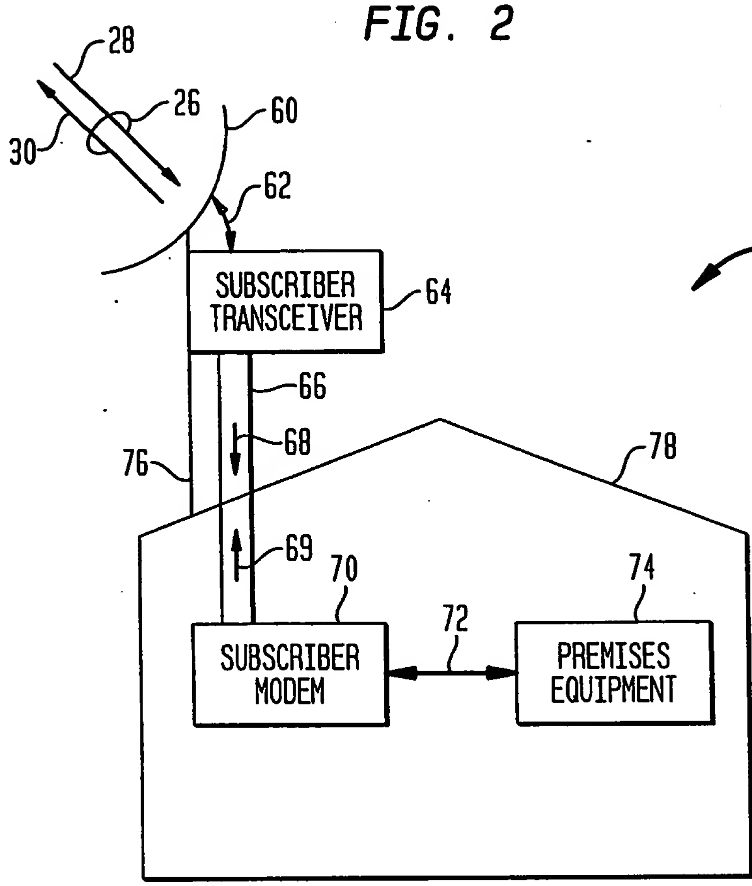
INFORMATION SOURCE/ EXCHANGE

FIG. 2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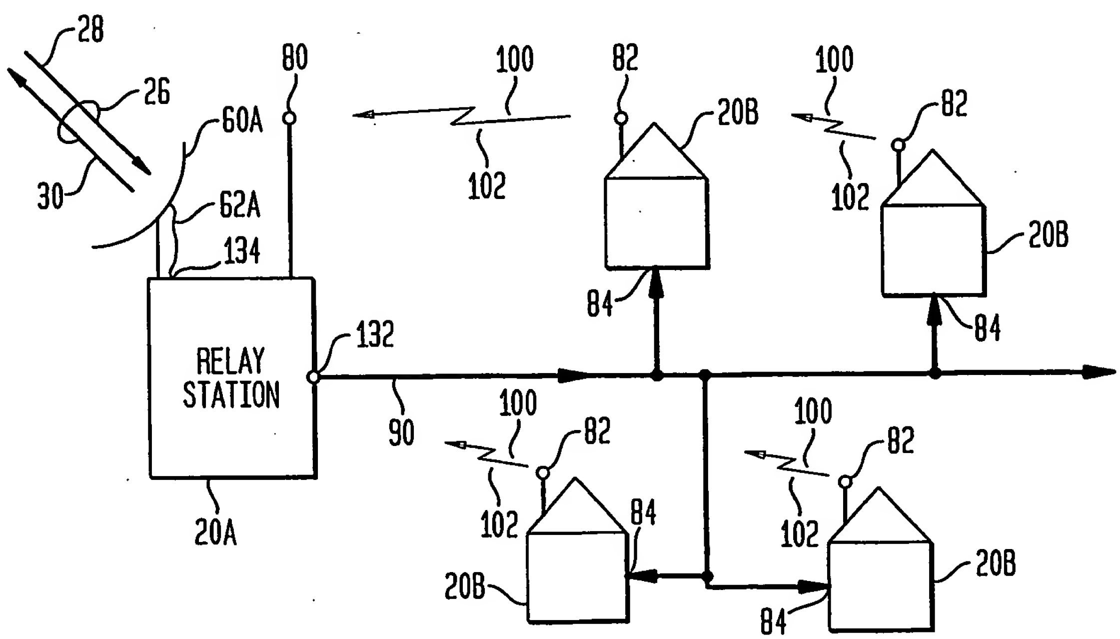
EQUIPMENT

FIG. 3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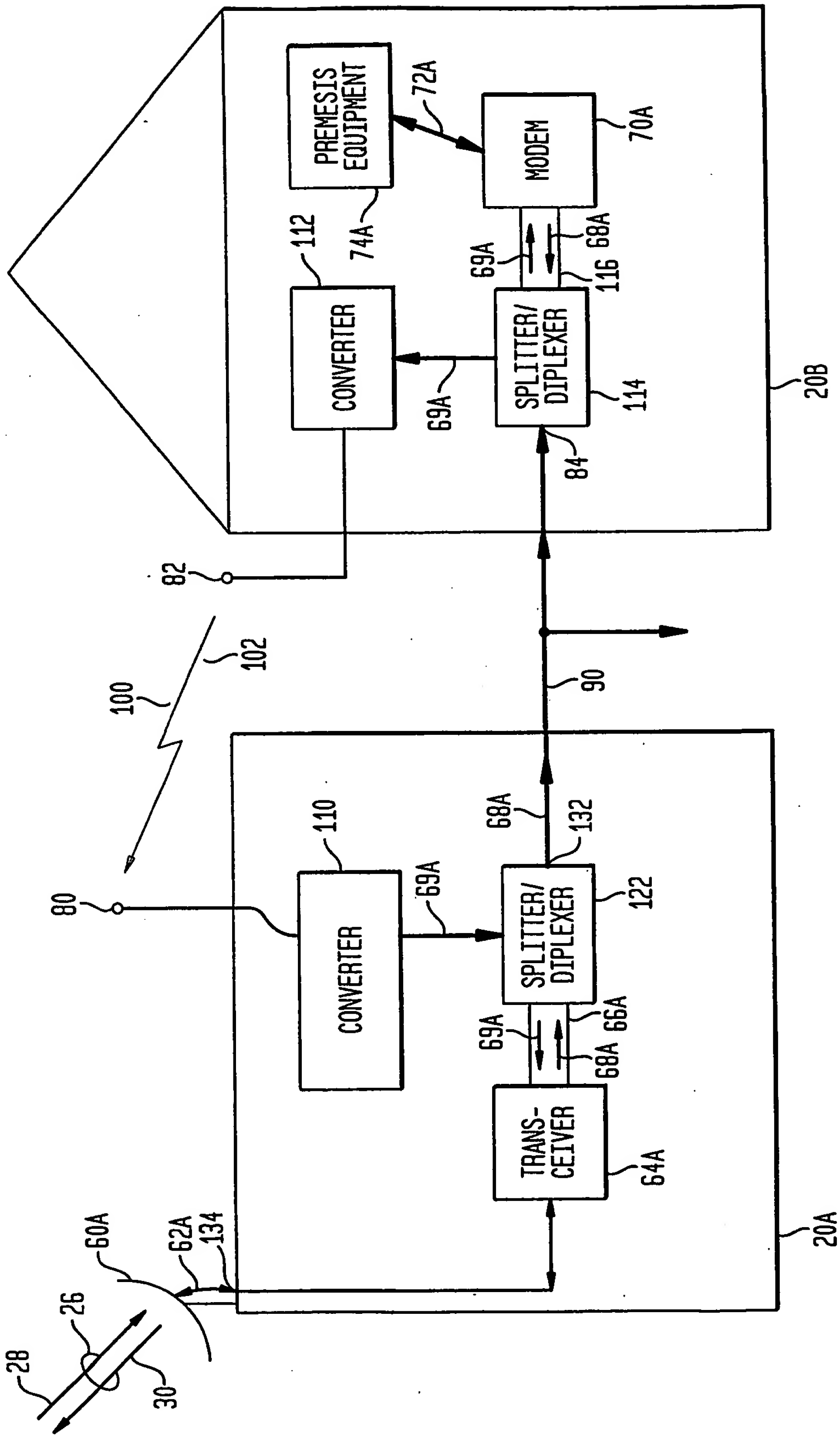
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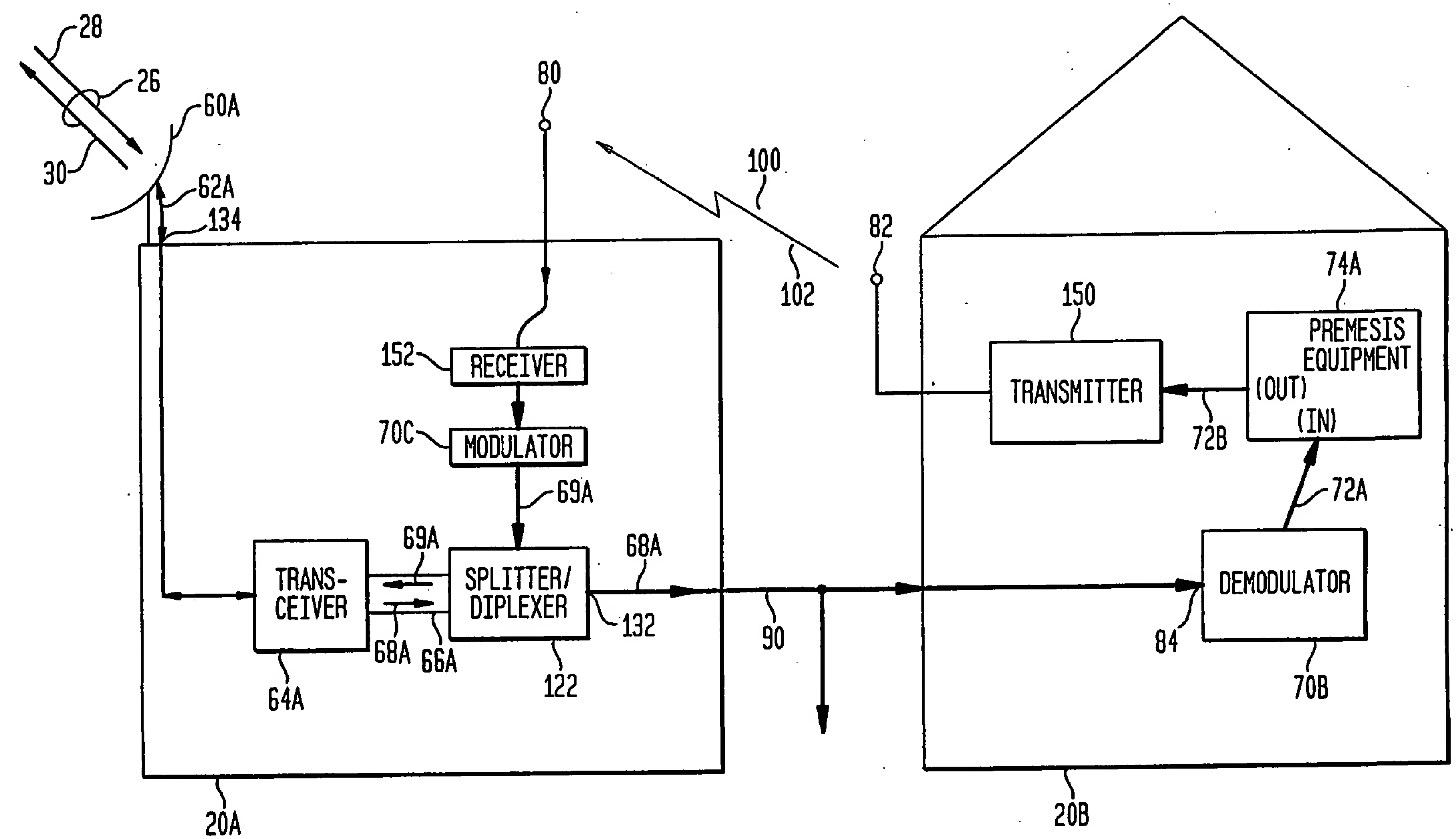
FIG. 4

FIG. 5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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/00241

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/173

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 613 191 A (BURTON WILLIAM ET AL) 18 March 1997 (1997-03-18)	1,13,25, 42,59, 75,87,88
A	the whole document	2-12, 14-24, 26-41, 43-58, 60-74, 76-86

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 April 2001	12/04/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Greve, M

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 809 431 A (BUSTAMANTE HERMAN ET AL) 15 September 1998 (1998-09-15)	1,13,25, 42,59, 75,87,88
A	the whole document	2-12, 14-24, 26-41, 43-58, 60-74, 76-86
Y	WO 97 48191 A (BUGAS DMITRY ;GRAVES H DAVID (CA); BROADBAND NETWORKS INC (CA); SC) 18 December 1997 (1997-12-18)	1,13,25, 42,59, 75,87,88
A	page 3, line 19 -page 17, line 15	2-12, 14-24, 26-41, 43-58, 60-74, 76-86
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A	the whole document	2-12, 14-24, 26-41, 43-58, 60-74, 76-86
A	US 5 838 670 A (BILLSTROEM JAN-OLOF) 17 November 1998 (1998-11-17) column 1, line 1 -column 2, line 5	1-88
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A	US 5 613 190 A (HYLTON DENNY L) 18 March 1997 (1997-03-18) abstract	1-88

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			US	5630204	A	13-05-1997
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			US	5793413	A	11-08-1998
US 5809431	A	15-09-1998	AU	723186	B	17-08-2000
			AU	1078197	A	27-06-1997
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			CA	2237463	A	12-06-1997
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